A Search for New Physics using DØ Run 1 Data

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Goal of this exercise: explore the limits that can be placed on the production of technicolor particles using the data already taken at the Tevatron in 1992-95. Extrapolate to Run 2.

We will use the public interface to DØ Run 1 data, which is called Quaero.

1. First, look at the PRL article describing Quaero:

http://www-d0.fnal.gov/www_buffer/pub/pub_228.pdf or
http://www-d0.fnal.gov/www_buffer/pub/pub_228.ps

You'll see (in Table III of the paper) a number of channels where limits were set, including $\bar{p}p \rightarrow WH \rightarrow e\nu jj$. The paper did not, however, set limits on the technicolor process with a similar final state, $\bar{p}p \rightarrow W\pi_T \rightarrow e\nu jj$. It is suggested that this process may have a much higher cross section than the Higgs process, so it's interesting to see what can be done with the relatively low luminosity accumulated in Run 1.

This process, and a suggested search strategy, are described in:
http://arxiv.org/abs/hep-ph/9704455

2. Go to the Quaero website: http://quaero.fnal.gov

Look at the examples to see what one can do with this interface. You can ask Quaero to generate the signal events itself, using Pythia, or you can feed it an input file. In this case we'll ask it to use Pythia because Technicolor is implemented in Pythia.

The Pythia web page is http://www.thep.lu.se/~torbjorn/Pythia.html but a more useful short guide from LAPP can be found at http://wwwlapp.in2p3.fr/Pythia/. Page 28 and 29 of the short guide (PDF version) describe the technicolor implementation.

3: Now let's set up our search.

Under "signal"

- Select the final state corresponding to $e\nu jj$ (e met 2j (nj))
- Select "smear" (we want the detector resolutions to be modelled)
- Select "Pythia input" since we want Quaero to generate the technicolor events itself.
- Enter the Pythia commands to generate $W\pi_T$ events: The easiest way is MSEL=50 which turns on all the technicolor processes.
- Click on "search" (that's what we want to do)

- Check the boxes corresponding to the backgrounds to be considered

Now under "variables:

- If you like, enter a constraint (e.g. you could constrain the e and the missing E_T to be a W). This is optional.
- Enter up to 3 variables in which Quaero will search for signal events: the hep-ph paper suggests the p_T of the W, the p_T of the dijet system, $\Delta\phi(jet_1, jet_2)$, and the mass of the dijet system.

Under "Requestor," enter your name and e-mail, and a short note describing what you are doing (please mention TASI).

4. Now click "submit"!

Stay logged in – if there are errors in the submission, Quaero will bounce an e-mail right back to you.

5. Check your e-mail tomorrow for the results.
See the examples on the following pages for typical output.

6. What limit did you get? How do this limit, and the Pythia cross section reported by Quaero, compare with the expected theoretical cross section from the hep-ph paper? Remember that Quaero quotes limits on (cross section × branching ratio), so you'll have to multiply by 9 to remove $B(W \rightarrow e\nu)$. How much more luminosity would it take to observe a signal in Run 2?

7. If you have time, try optimizing the constraints or variables to see if you can get a better limit on the same process. Try constraining the e and Missing E_T to a W mass, for example, if you didn't already. Try other variables which might be better than mine.

Quaero FAQ:

1. Yes, this is real collider data.
2. Yes, if you find a signal you can publish it.

Here is an example Quaero submission:

Quaero

A General Interface to DØ Data

Article Manual
Examples

This web page provides an interface to data collected by the DØ experiment at the Fermilab Tevatron, enabling fast and automatic testing of models predicting new phenomena at the scale of several hundred GeV. The links above provide directions for use; more detailed help is available on the links below. Results in the form of cross section limits are returned by email, typically within one day of submission.

Signal

Final State: e met 2j (nj) Smear? ☑

msel=50

Pythia Input:

Signal File: Browse... xsec: pb

View Search

Backgrounds: ☑ (nj) ☑ W(nj) ☑ Z(nj) ☑ VV(nj) ☑ tt(nj)

Variables

Constraints:

Variables:

v1 deltaphi(j1,j2)
v2 (e+met)_pt
v3 mass(j1,j2)

Requestor

Name: John Womersley
Institution: Fermilab
Email: womersley@fnal.gov

Brief description of model:

Test for summer school excercise

Submit

Help! - Bug history - DØ - Fermilab - Press

Example of the e-mail response:

From: quaero@fnal.gov
Date: Mon, 20 May 2002 15:57:54 -0500
To: womersley@fnal.gov

Dear John Womersley:

The result of your Quaero analysis is attached. Please include the accompanying reference in any publication that uses this result.

Regards,
The DZero Collaboration

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\bibitem{Quaero}
D\O\ Collaboration,
V.~Abazov {\sl et al}.,
hep-ex/0106039;
\#241 Mon May 20 2002.

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To: John Womersley <womersley@fnal.gov>
Subject: Quaero Request #241

FinalState
e met 2j (nj)

Constraints
none

Variables
deltaphi(j1,j2)
(e+met)_pt
mass(j1,j2)

DZero cuts: standard(e1)&&(e_pt>20) && (met_pt>30) && standard(j1)&&(j1_pt>20) && standard(j2)&&(j2_pt>20) && (mass(e,met)>30) && ((e1+met)_pt>40) && (deltaphi(j1,met)>0.25)&&(deltaphi(j2,met)>0.25)

Requestor
John Womersley
Fermilab
womersley@fnal.gov

ModelDescription
Test for summer school excercise

Pythia commands
msel=50

Result

Pythia cross section x branching ratio = 0.58 pb.

Upper limits on the cross section to this process at confidence levels of 50%, 90%, and 95% are found to be 0.5 pb, 1.5 pb, and 1.8 pb, respectively. Maximal sensitivity (0.635 pb^-1) is achieved in a region of variable space with 2.9 signal events expected, 23.4 +- 5.4 background events expected, and 14 events observed in the data.

Plots

Plots of the variables that you used are available for viewing at http://quaero.fnal.gov/quaero/requests/plots/241.ps. The red curve is the expected background; the green curve is your signal multiplied by a factor of 50; the black dots are D0 data.

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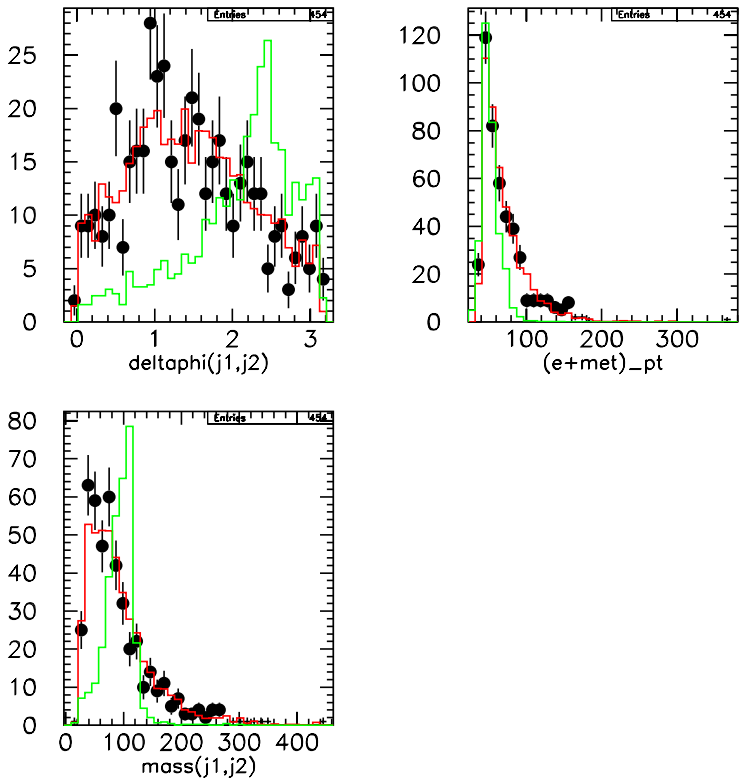
Please keep the following caveats in mind when interpreting this result:
* Your signal has been run through a fast detector simulator.
* Your signal has been generated with Pythia. Any inadequacy in Pythia's modeling of the signal process will propagate into a corresponding inadequacy in Quaero's result.
* If attempting multiple analyses of the same signal, you should quote as the final answer the result corresponding to the greatest sensitivity.
* No attempt has been made to assess the stability of this result under changes in parton distribution functions, initial and final state radiation, or other assumptions that may affect the characteristics of your signal.

Example of the plots that are produced:



The plots show the three variables I specified in my search. The black points are the data, the red curve is the background, and the green is the signal expected multiplied by 50. You can see that the deltaphi and mass variables give quite good distinction between signal and backgound, but the p_T variable isn't so great. Try to do better!